Dec. 20, 1949 J. B. MINTER, II 2,491,681

ELECTRIC FILTER

Filed Dec. 11, 1944 2 Sheets-Sheet 1

Fig. 1.

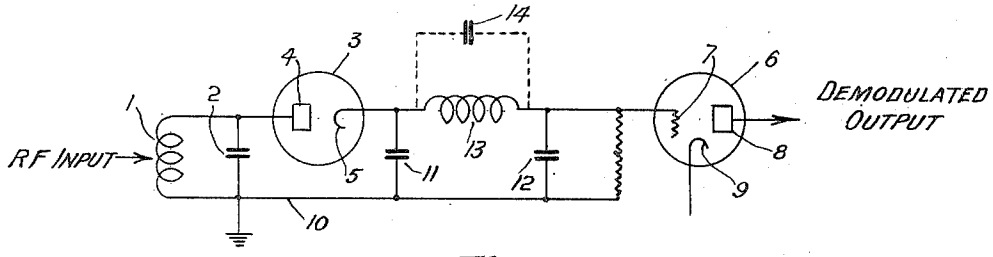


Fig. 2.

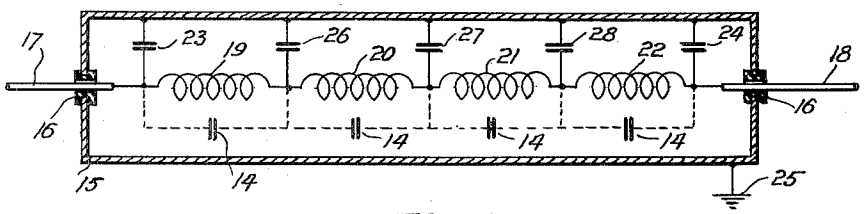


Fig. 3.

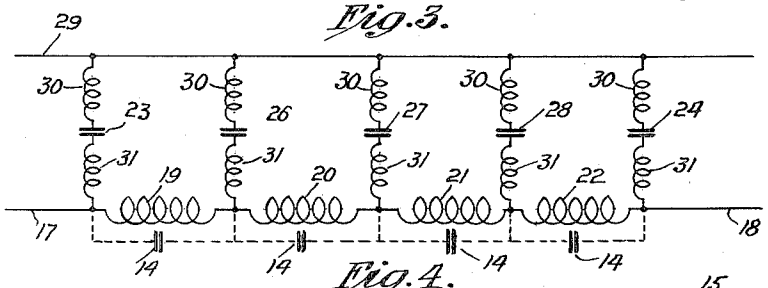


Fig. 4.

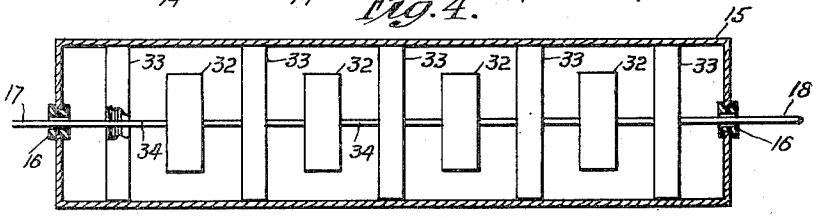
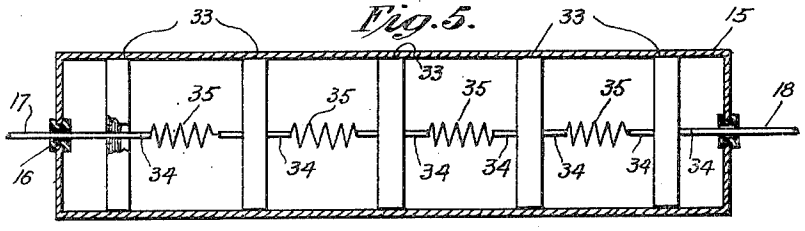


Fig. 5.



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Fig. 6.

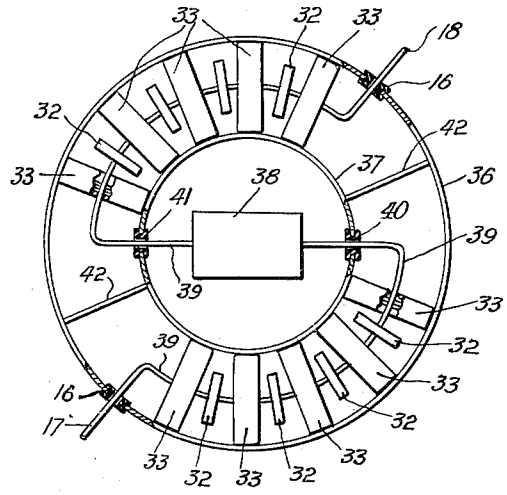
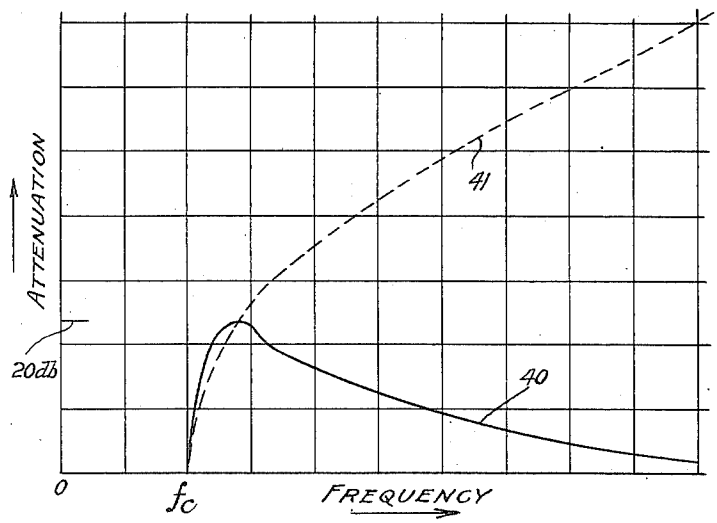


Fig. 7.



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Patented Dec. 20, 1949 2,491,681

UNITED STATES PATENT OFFICE

2,491,681

ELECTRIC FILTER

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Application December 11, 1944, Serial No. 567,710

1 Claim. (Cl. 178—44)

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This invention relates to an electric filter device employed for the suppression or attenuation of a band of frequencies.

More particularly this invention relates to a filter device which is capable of rejecting, or attenuating to a desired degree, a band of frequencies of very great width.

One object of this invention is to provide an electric filter which may be employed where it is desired to suppress a very wide band of frequencies, while passing with very slight attenuation, frequencies lying outside such band.

Another object of this invention is to provide a filter useful in television systems and the like, where it is needful to pass, in certain portions of the system, all frequencies lying between widely spaced limits, for example from twenty cycles to several megacycles.

A further object of this invention is to provide a filter in which the distributive capacity of the inductance coils forming part thereof is reduced in magnitude, thereby increasing the efficiency of such coils as to frequency discrimination.

A still further purpose of this invention is to provide a filter for the detector output of a television receiver or the like, which shall reject substantially all the frequencies lying above the video range, or above some other predetermined frequency.

Yet another purpose of this invention is to provide an electrical filter in the form of a unitary structure which shall be self-shielded, compact and efficient.

Still another object of this invention is to provide a form of filter in which a plurality of individual cells are incorporated within a single outer casing, which latter serves both to reduce undesirable distributive capacity effects in the inductance coils of the filter, and to act as a shield preventing interaction of any field produced by filter elements with an external field in which the filter device may be located.

Another purpose of this invention is to provide a sectional filter in which the walls separating and shielding the individual cells are constituted by the capacity elements of the filter, thus doing away with the need for separate shielding walls for such cells.

Still another purpose of this invention is to provide a sectionalized filter in which a series feed-through circuit constituting a transmission line is employed, whereby there is obtained a very great reduction of the undesirable inductive and resistive components of the impedance presented by the capacitative elements of the filter, especially at very high frequencies.

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A yet further object of this invention is to provide an electrical filter of the transmission line type in which terminal reflection is reduced to a minimum.

Yet another object of this invention is to provide a sectionalized filter of the resistance-capacity type in which the individual cells have at least two contiguous boundaries constituted by a condenser of the disk type, and each disk intermediate the terminal disks serves simultaneously partly to bound two cells, thereby affording maximum shielding with the need of minimum material.

Another object is to provide a filter of the type just described, but of the inductance-capacity type, in which disk condensers also perform the dual functions just set forth.

A still further purpose is to provide a compact and self-shielded filter in which the number of sections may readily be altered, while yet maintaining high efficiency and complete inter-cell shielding.

Finally, this invention has the object of providing a combination filter and shielding structure for enclosing a device and feeding energy thereto, or withdrawing energy therefrom, via a series of series-connected filter units, which at the same time form a part of the shielding system.

Other purposes and objects of the instant invention will be apparent to those skilled in the art.

Reference is now made to the accompanying drawings, where:

Fig. 1 is a schematic diagram of a portion of the circuit of a receiver capable of handling a wide band of frequencies.

Fig. 2 is a partly schematic showing of a multi-section filter of one type hitherto employed in the art.

Fig. 3 is a schematic diagram illustrating the electrical equivalent of the device of Fig. 2.

Fig. 4 shows, partly in cross-section, an inductance-capacity type filter constructed according to this invention.

Fig. 5 shows, partly in cross-section, a filter similar to that of Fig. 4, but of the resistance-capacity type.

Fig. 6 illustrates a combination filter and shielding structure according to this invention.

Fig. 7 is a graphic representation of performance of a filter constructed according to this invention, and of a prior art filter.

In Fig. 1, an input circuit constituted by coil 1 and condenser 2 receives intelligence-bearing radio signals having both high and low frequency components. Such signals are fed to this input circuit via any suitable means, not here shown, such as inductive, capacitative or resistive coupling thereto. Diode detector 3, having anode 4 and cathode 5, rectifies the signals in known fashion and feeds the demodulated components to triode 6, having input grid 7, output anode 8 and cathode 9.

The potentials developed between electrode 5 and grounded conductor 10 carry not only the desired low-frequency components, but also residual and undesired high-frequency components, which latter may cover a wide band of frequencies, especially if television signals are being received. Accordingly such undesired high-frequency components should be substantially eliminated between the output of diode 3, and the input of triode 6. Shunt condensers 11 and 12, connected via choke coil 13, constitute a filter designed to eliminate these undesired high frequencies.

However, the unavoidable distributive capacity of coil 13, schematically indicated by condenser 14, prevents this coil from functioning as a pure inductance, and thereby lessens the effectiveness of the filter system.

In order to increase the effectiveness of the filter system 11, 12, 13, it is customary to increase the number of individual units making up such filter system. In Fig. 2 there is shown a multi-cell filter embodying a number of individual filter units. In order to shield this filter from external fields, it may be enclosed in the metallic container or shield indicated at 15. This shield is provided at convenient points with insulating bushings 16, through which pass input and output conductors 17 and 18, respectively. Within the shield are indicated a number of inductances, 19, 20, 21 and 22, but it is understood that any other suitable number of such inductances may be incorporated in the same composite filter. Condensers 23 and 24 are connected from the input and output ends, respectively, of the filter, to the actual metal shield itself. Since the shield is grounded, as indicated at 25, the longitudinal wall of the filter, to which one side of such condenser is connected, will function as one conductor of the transmission line connecting the two extremities of the filter. Additional condensers 26, 27 and 28 are connected from the common junction points of each pair of inductances to the metal shield. The capacities indicated at 14 are thus due to the distributive and stray capacity unavoidably present in each inductance. While such undesired capacities are reduced in effective value by the placing of the inductances within a metallic shield, such unwanted capacities still exist and cause the undesirable effects previously described.

Reference is now made to Fig. 3 where the electrical equivalent of the device of Fig. 2 is schematically indicated. The grounded metallic shield is here indicated by the same reference numerals as in Fig. 2. The inductances 30—30 shown extending between the upper side of each condenser and the grounded line represent the unavoidable inductance of the conductors employed to connect the actual physical condensers to the metallic shield, while inductances 31—31 similarly represent the unavoidable inductance present in the conductors extending from the lower side of each condenser to the particular

point to which such condenser is connected. While the quantitative value of inductances 30 and 31 may be quite low, yet the effect of such inductances becomes of increased importance as the range of frequencies, over which the filter as a whole is desired to function, extends into the region of megacycles. The distributive capacities associated with the various inductances are likewise here indicated by condensers 14—14. From a consideration of the circuit here shown, it is evident that the total filter effect will be by no means the one which can be predicated for the construction of a multi-cell filter employing pure inductances and pure capacities.

In Fig. 4 is shown a multi-cell filter in which the undesirable effects of the unwanted capacities and inductances above mentioned have been greatly reduced. The outer shield 15, bushings 16—16 and conductors 17 and 18 are identical with these same elements described in connection with Fig. 2. The inductance coils 32—32 are formed so that the turns thereof approach the inner walls of shield 15, thereby reducing the effects of the unavoidable distributive capacities associated with each coil. The reasons for keeping distributive capacities at a minimum and this method of reducing such undesired distributive capacity effects are well-known in the art, reference being made to United States Patent 2,258,261 issued to Roosenstein, so that detailed description thereof is considered unnecessary. The condensers 33—33 are of the radially extending type. As indicated in the cut-away section shown, each of these condensers comprises a number of disks. Each alternate disk extends from the central conductor 34, almost to, but not reaching, the inner periphery of the shield 15, which latter is formed as a metallic cylinder. Conductor 34 extends uninterruptedly so as to join conductors 17 and 18 into a continuous transmission line, interrupted only at the respective points occupied by inductances 32—32. Between the alternate condenser disks just described lie another set of disks, each having a larger diameter, so that the peripheries thereof come into close contact with the internal wall of cylindrical shield 15. Each of the latter set of disks is provided with a larger central aperture, so that it cannot come into contact with conductor 34, this latter conductor constituting an axis upon which both sets of disks are supported so that the centers thereof coincide with the longitudinal axis of cylindrical shield 15. Between the respective sets of disks are located a number of disks of suitable dielectric material, such as mica. This third set of dielectric disks extends over substantially the entire radial distance between central conductor 34 and the inner wall of cylinder 15. Certain forms which a condenser such as that just described may assume, are well known in the art, for example being described and illustrated in U. S. Patent 1,571,501 to Van Deventer, and U. S. Patent 934,714 to Denieport, so that a detailed illustration thereof would be superfluous.

The current distribution in condensers 33 is such that the effect of any inductance thereof is very small. Since the current may be considered as flowing radially outward from conductor 34 toward the entire internal circumference of cylinder 15, all the inductances, when considering any single radial direction, may be looked upon as being in parallel with one another, so that the total inductance is thereby minimized. The effective impedance of a condenser con-

structed in this fashion is extremely low, even at extremely high frequencies. The fact that transmission line conductor 34 extends through the axis of condenser 33, gives rise to still further reduction in losses due to transmission line reflection and the like.

The disk-type condensers 33 perform still other functions. Due to the fact that they extend completely from the axis to the internal periphery of cylindrical shield 15, they serve to subdivide the interior portion of this cylinder into a number of cells substantially completely shielded from one another, each cell containing therein a suitable inductance coil 32. There is thus obtained a complete lateral shield between the individual cells of the filter, the desirability of which feature is well known in the art. Furthermore, the metallic shield thus afforded adjacent the lateral surfaces of inductance coils 32 brings about a still further reduction in the undesirable distributive capacities of such coils, as previously explained in connection with the action of cylindrical shield 15. Due to the peculiar manner in which conductor 34 traverses from one cell to the adjacent cell, through the body of the condenser 33, this condenser simultaneously serves as an insulating bushing preventing the short-circuiting of conductor 34 to the grounded shield 15. It is thus to be seen that a large number of advantages are obtained by the form of construction used in this invention. Some of these advantages are derived from the use of a single element to perform a plurality of functions.

In Fig. 5 is shown a variant form of this invention in which the inductance coils 32, of Fig. 4, are replaced by resistances 35—35. The construction and arrangement of the condensers 33 are similar to those just described in connection with Fig. 4. The resistance-capacity type filter shown in Fig. 5 may frequently be employed where the inductance-capacity type of Fig. 4 is less desirable, for example by reason of bulk, greater expense, etc. In the form of Fig. 5, the individual cells are still wholly shielded from one another and the undesirable inductive and resistive impedances of condensers 33 are greatly minimized. Since resistances 35 may be made, in general, to have less distributive capacities than similar capacities inherent in inductance coils, a filter of the type shown in Fig. 5 may frequently be made to be very effective, especially upon high frequencies, and where the voltage drop caused by current flow through resistances 35 is either negligible or does not introduce some undesirable effect into the circuit as a whole.

While I have described metallic shield 15 and the constituent plates of condensers 33 as having a circular periphery, i. e. as being, respectively, a cylinder and disks, it will be apparent that such limitation as to form is not necessary. While inductance coils 32 are usually made in a more or less cylindrical or disk form, under which condition a cylindrical shield 15 will function more favorably with respect to such coils, yet in the case of a resistance-capacity filter, there is little reason why shield 15 cannot be formed of rectangular cross-section, while the radially extending elements of condensers 33 can also be formed of a similar shape, so that the external peripheries of the respective elements will coincide with the internal periphery of shield 15. Such form of condenser elements may allow less waste in manufacturing from large sheets of raw material, and a square or rectangular condenser will naturally allow each condenser unit to be of a greater capacity, due to the greater effective dielectric area possible. On the other hand, in cases where extreme compactness is desirable, a rectangularly shaped filter unit may very often occupy no greater effective space than would a cylindrically shaped filter unit having a diameter equal to one side of such rectangular unit. Likewise, the cells do not necessarily extend in a single direction, but may be arranged to abut one another in several directions and may be connected in parallel, or in series-parallel.

In Fig. 6 are shown two concentric metallic shielding cylinders, 36 and 37. Within the smaller cylinder, 37, is indicated an electrical device 38. Device 38 may be any electrical device which it is desired to shield from external fields and to or from which it is desirable to lead an electrical circuit with the incorporation in the lead wires, extending from such device, of filter systems, so that current reaching or leaving such device shall be suitably filtered. As one non-limiting example of such device, 38 may be an electro-mechanical or electro-optical transducer and the external feed circuit to which such transducer is connected may be carrying, not only frequencies to which the transducer is designed to be responsive, for producing some useful effect, but such feed circuit may also be carrying other frequencies which would cause undesirable action upon transducer 38. The electrical circuit may be traced from one lead 17, passing through insulating bushing 16 in outer cylinder 36. Conductor 17 joins conductor line 39 which is concentric with shields 36 and 37, and extends through a portion of the annular space between these cylinders, before entering inside the cylinder 37 through an insulating bushing 40. After leaving the device 38, transmission conductor 39 extends outwardly through another bushing 41 into another portion of the annular space between cylinders 36 and 37, and eventually joins lead 18, passing outwardly through cylinder 36, via insulating bushing 16. Along the portion of line conductor 39 lying between bushing 16 and bushing 20 are placed a series of condensers 33 and inductance coils 32. These coils and condensers may be of the same types already shown in connection with Fig. 4. The condensers 33 perform the various functions already described, breaking up the filter into a series of completely shielded individual cells, in each of which is located a single inductance coil 32. Current from conductor 39 which passes through bushing 40 will accordingly be completely filtered by the action of the multi-unit filter through which it is passed. The same results obtain along the portion of conductor 39 between bushing 41 and lead wire 18, by the action of a similarly placed and similarly constructed multi-cell filter, comprising additional condensers 33 and inductance coils 32. Metallic shields 42, 42 are preferably placed between the two portions of the space between the cylinders 36 and 37, so that each of the input and output branches of conductor 39 will be shielded from the filter cells which are located in the other branch of conductor 39.

It can be understood that device 38 may be a source of multi-frequency current, instead of a current consuming device, in which case the filtered current will appear at leads 17 and 18. The number of cells and the degrees of arc over which each filter extends may be varied in any particular case. Likewise, by making each filter extend over a smaller arc, more than two conduc-

tors may lead to or from device 38 and each conductor may be suitably filtered. Cylinders 36 and 37 thus perform the dual function of shielding device 38 and constituting the shielding portion of the multi-cell filters lying between the two cylinders.

In Fig. 7, the graph 40 represents the attenuation, plotted against the frequency, of a representative filter employing conventional construction, and designed to give high attenuation for all frequencies lying above f_c. It will be noted that the maximum attenuation yielded by this filter is about 20 db at the frequency f_c. However, when the frequency is increased, the attenuation falls off quite rapidly.

In Fig. 7, the graph 41 shows the performance of a filter designed for the same purpose as that just described, but constructed according to the present invention. It will be noted that this filter not only gives a substantial degree of attenuation at the frequency f_c, but the attenuation increases steadily as the frequency rises. Comparing these two graphs, it is evident that the conventional type of filter will offer little protection against the passage therethrough of frequencies having a numerical value several times greater than f_c, while a filter constructed according to this invention will afford at least the desired degree of attenuation over an extremely wide band of frequencies, for example, extending to values manifold that of f_c.

While there have been shown and described several embodiments of this invention, it is to be understood that such embodiments are illustrative and not restrictive, and that the scope of this invention is limited only by the claim hereunto appended.

What I claim is:

A combination shield and filter, including two concentric cylinders formed of conducting material, an electric device located within the inner cylinder, at least one lead entering the space between said cylinders from the outside and at least one lead entering therewithin from the inside, a transmission line arcuately formed and connecting said two leads, and condensers and non-capacitative filter elements serially and alternately disposed along said transmission line, said condensers being formed so that the peripheries thereof make contact with the facing surfaces of said cylinders so as to subdivide the inter-cylinder space into a series of filter-cells, in each of which is located one of said non-capacitative filter elements.

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